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Durability Study of High Early Strength M40 Grade Concrete

Patel Vatsal N.[1], Soni Vivek A.[2], Chauhan Shyamal A.[3], Tandel Ujjval U.[4], Maniya Jay L.[5]

[1]A.D Patel Institute of Technology, New V V Nagar, India
[2]A.D Patel Institute of Technology, New V V Nagar, India
[3]A.D Patel Institute of Technology, New V V Nagar, India
[4]A.D Patel Institute of Technology, New V V Nagar, India
[5]A.D Patel Institute of Technology, New V V Nagar, India

Abstract

The main aim of experimental study is to see the durability of high early strength concrete and to see the behaviour of the high early strength concrete in very severe exposure conditions and severe weathering exposures.

M40 grade high early strength concrete was prepared and checked its behavior in real practical severe exposure conditions like sea water exposure, acid exposure and fire exposure. Cubes of size 150mm*150mm*150mm were cast for high early strength and its mechanical property was compared by performing compression test with control concrete. Also its durability behavior was checked by exposing the high early strength concrete to the severe most exposures as specified above and compared with control concrete. The results showed that the behavior of early strength concrete was better in comparison with control concrete at all ages.

1. Introduction

Concrete durability has been defined by the American Concrete Institute as its resistance to weathering action, chemical attack, abrasion and other degradation processes.

Durability is the ability to last a long time without significant deterioration. A durable material helps the environment by conserving resources and reducing wastes and the environmental impacts of repair and replacement. Construction and demolition waste contribute to solid waste going to landfills. The production of new building materials depletes natural resources and can produce air and water pollution the design service life of most buildings is often 30 years, although buildings often last 50 to 100 years or longer. Most concrete and masonry buildings are demolished due to obsolescence rather than deterioration. A concrete shell can be left in place if a building use or function changes or when a building interior is renovated. Concrete, as a structural material and as the building exterior skin, has the ability to withstand nature's normal deteriorating mechanisms as well as natural disasters.

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different concretes require different degrees of durability depending on the exposure environment and properties desired. For example, concrete exposed to tidal seawater will have different requirements than an indoor concrete floor. Concrete ingredients, their proportioning, interactions between them, placing and curing practices, and the service environment determine the ultimate durability and life of concrete.

Seawater Exposure: Concrete has been used in seawater exposures for decades with excellent performance. However, special care in mix design and material selection is necessary for these severe environments. A structure exposed to seawater or seawater spray is most vulnerable in the tidal or splash zone where there are repeated cycles of wetting and drying and/or freezing and thawing. Sulphates and chlorides in seawater require the use of low permeability concrete to minimize steel corrosion and sulphate attack. A cement resistant to sulphate exposure is helpful. Proper concrete cover over reinforcing steel must be provided, and the water-cementitious ratio should not exceed 0.40.

Chloride Resistance and Steel Corrosion: Chloride present in plain concrete that does not contain steel is generally not a durability concern. Concrete protects embedded steel from corrosion through its highly alkaline nature. The high pH environment in concrete (usually greater than 12.5) causes a passive and non corroding protective oxide film to form on steel. However, the presence of chloride ions from de-icers or seawater can destroy or penetrate the film. Once the chloride corrosion threshold is reached, an electric cell is formed along the steel or between steel bars and the electrochemical process of carrions begins.

The resistance of concrete to chloride is good; however, for severe environments such as bridge decks, it can be increase by using a low water-cementitious ratio (about 0.40), at least seven days of moist curing, and supplementary cementitious materials such as silica fume, to reduce permeability. Increasing the concrete cover over the steel also helps slow down the migration of chlorides. Other methods of reducing steel corrosion include the use of corrosion inhibiting admixtures, epoxy-coated reinforcing steel, surface treatments, concrete overlays, and cathodic protection.

Resistance to Alkali-Silica Reaction (ASR): ASR is an expansive reaction between reactive forms of silica in aggregates and potassium and sodium alkalis, mostly from cement, but also from aggregates, pozzolans, admixtures, and mixing water. The reactivity is potentially harmful

only when it produces significant expansion. Indications of the presence of alkali-aggregate reactivity may be a network of cracks, closed or spalling joints, or movement of portions of a structure. ASR can be controlled through proper aggregate selection and/or the use of supplementary cementitious materials (such as fly ash or slag cement) or blended cements proven by testing to control the reaction.
Abrasion Resistance: Concrete is resistant to the abrasive affects of ordinary weather. Examples of severe abrasion and erosion are particles in rapidly moving water, floating ice, or areas where steel studs are allowed on tires. Abrasion resistance is directly related to the strength of the concrete. For areas with severe abrasion, studies show that concrete with compressive strengths of 12,000 to 19,000 psi work well.

2. Materials and Properties

2.1 Cement
The cement used in this experimental effort is Ultratech 53 grade Ordinary Portland Cement. The specific gravity of this cement is 3.15. Standard consistency of cement was 31.5%. All properties of cement had tested by referring IS 12269 – 1987.

2.2 Fine Aggregates
Domestically available sand of Bodeli is use in this research. Sand passing from 4.75 mm sieve and of specific gravity of 2.63 and fineness modulus of 2.84 are used.

2.3 Coarse Aggregate
Aggregate of size 20 mm and 10 mm available from the domestic site Sevalia are used. Specific gravity of course aggregate is 2.77 and fineness modulus is 6.59.

2.4 Water
Fresh potable water free from acid and organic substances was use for mixing and curing concrete.

2.5 Artificial plasticizer (Faircrete)
Faircrete plasticizer was used in concrete mix and water was reduced by 10% of same mix.

Table 1: Proportion of Faircrete

Plasticizer (ml)	cement (kg)
200	50
100	25

3. Experimental Work

Table 2: Mix Proportion

Material	Weight (Kg/m3)
Cement	463.5
Water	185.4
Fine aggregate	530.27
Coarse aggregate	1153.13
W/C ratio	0.40

3.2 Casting and Curing

Casting had done as per combinations shown in Table 2. As per the details given in table 2, we first prepare the batches of sand, cement and aggregates for 6 cubes. We repeated process for5 times for making 30 cubes (15 normal and 15 with plasticizer).
Mixing of ingredients was done as per IS 516 (1959) by hand mixing. The concrete has first filled in layers of 5cm and compacted by table vibratos. The specimens had removed after 24 hours and submerged in water and has been leave for curing for 28 days.

4. Testing

Specimens with normal mix had tested to find out strength at 7 and 28 days.
Specimens with plasticizer had tested to find out strength at 7 and 28 days.
By performing following tests:
Compression test:
Compression test on cubes of size 150mm × 150mm × 150mm had performed on compression testing machine. Average compressive strength of three cubes had taken after 1, 3, 7 and 28 days for normal mix and mix made with plasticizer.

5. Results and discussion

The graphs shown in Fig 1, Fig.2 and Fig. 3 indicates the compressive strength in MPa for cubes.

Fig.1 shows the Compressive strength for control concrete cubes and high early strength concrete cubes when exposed to acid after curing for 28 days.

Fig.2 shows the Compressive strength for control concrete cubes and high early strength concrete cubes when exposed to fire after curing for 28 days.

Fig. 3 shows the Compressive strength for control concrete cubes and high early strength concrete cubes when exposed to sea water for 7 and 28 days after curing for 28 days.

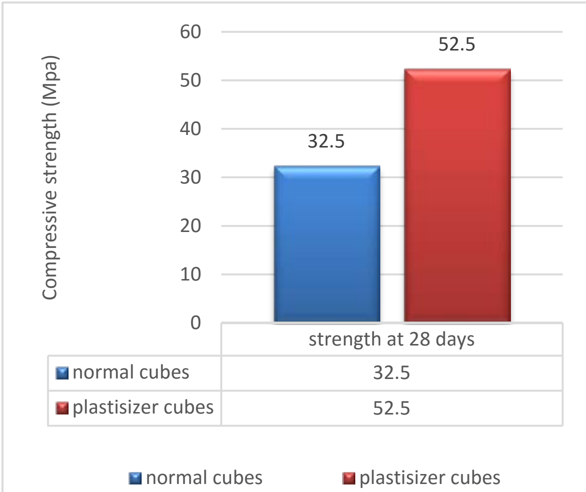

Fig.1 Compressive strength when exposed to acid

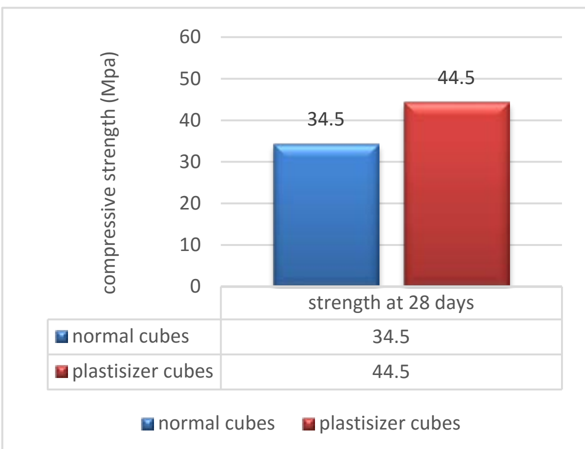

Fig.2 Compressive strength when exposed to Fire

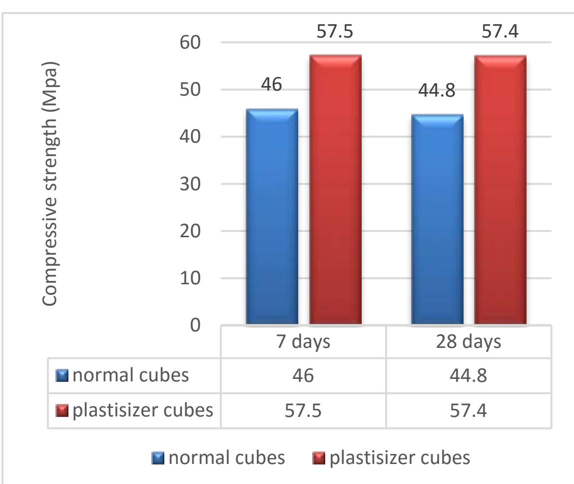

Fig.3 Compression strength when exposed to sea water

5.Conclusions

From experimental study it was concluded for M40 grade of normal concrete and with plasticizers the following.

1. Acidic Exposure

• From Fig. 1 it is concluded that for high early strength concrete the compressive strength is almost 25% more than control concrete.

• For normal concrete for M40 grade the compressive strength reduces more as compared to high early strength concrete.

• Reduction in weight of the control concrete was more than that of high early strength concrete.

Fig.4 Concrete Exposed to Acid

2. Fire Exposure

• By heating both types of concrete specimens at 750◦c as shown in Fig.5 for 30 minutes it was observed that.

• From Fig.2 we can conclude that the compressive strength of high early strength concrete is almost 75% more than that of control concrete.

• From our experimental study it is observed for control concrete as following with compared to high early strength concrete.

a. For control concrete cracks was observed.

b. Also the surface was deteriorated.

c. Also cracks were observed on control concrete.

d. The edges of the normal concrete busted in contact with fire of 750^{0}C, and the edges became uneven as shown in Fig.6.

Fig.5 Concrete Exposed to Fire

Fig. 6 Effect of Fire on Concrete

3. Sea Water Exposures

Fig. 7 shows cubes exposed to sea water. From Fig.3 it is concluded that the compressive strength of high early strength concrete is almost 20% more at 7 days than control concrete, and almost 25% more for 28 days.

For high early strength concrete there is no compressive strength reduction from 7 to 28 days as compared to control concrete.

Fig.6 Concrete Exposed to Sea water

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